LOGARITHMIC

AND

PHYSICAL TABLES

WITH INSTRUCTIONS

With the best Compliments
of the author.

BY

T S. KRISHNASWAMI AYYAR, M. A., L. T.

LECTURER, GOVERNMENT COLLEGE, KUMBAKONAM

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PREFACE

The use of the logarithmic tables in physical calculations requires an elementary knowledge of the properties of the logarithms and is best understood by a few typical examples, actually worked out. The aim of this publication is to provide the beginner with the necessary preliminary instructions, which are however lacking in most of the compilations in use.

The mathematical tables (logarithms, antilogarithms, natural sines and natural tangents) have all been based upon the seven figure tables of Hutton and Gregory (Eleventh Edition) published as early as in 1849 and the more recent tables by Chambers, the figures having been cut down to the nearest fourth figure in each case.

A table of natural cosines has not been provided, as the cosine of an angle could be easily obtained from the table of sines, by reading the sine of the complement. Tables of logarithmic sines and tangents are not included, as they are not necessarily required in simple physical calculations.

The reciprocal tables have been included by actually working out the reciprocals of the numbers from 10·0 to 99·9, correct to the third significant figure, as an accuracy of 1% will be sufficient for elementary practical work. Prominence has been given, in certain cases to the fifth column in the tables, by suitable spacing somewhat in the manner of certain tables among which may be mentioned the excellent edition of Kaye and Laby's Physical and Chemical Tables, which is indispensable to every advanced student of Physics.

Tables of the most commonly used physical constants are also provided for the easy reference of students in their Laboratory work. Though the needs of the Intermediate course have in the main been kept in view, an attempt has been made to include also the chief additional constants that may be required for reference in the practical course of the B. A. Degree Examination, such as the Moments of Inertia of certain bodies, the Elastic Constants of the common materials, the values of the Surface Tension and Viscosity of water at different temperatures, and the Wave Lengths of the prominent Fraunhofer Lines.

It is hoped that the definitions of most of the physical units and the expressions of a few important relations in the different branches of Physics may be found useful to the students.

T. S. K.

Note.—It was first proposed to give a table of the reciprocals of the integral numbers alone from 1 to 100. Hence, in the instructions, the method of obtaining by interpolation the reciprocals of numbers with one decimal figure (as for instance, 54·3 and 43·2) is explained. This was subsequently dropped and Table V where the reciprocals of numbers from 10·0 to 99·9 can be directly read to the third significant figure has been included instead.

CONTENTS

LOGARITHM.

Definition.

If a be any number, and x and b two other numbers, such that $a^x = b$, then x is said to be the logarithm of b to the base a, and is written as $\log_a b$.

The logarithm of a number to a given base is the index of the power to which the base should be raised in order to be equal to the given number.

Common logarithms.

In ordinary calculations, the number 10 is used as the base, owing to its great convenience and logarithms with 10 as the base are termed *common logarithms*. In such cases, the suffix denoting the base is omitted for the sake of brevity.

Thus since	$10^0 = 1$	$\log 1 = 0$
	$10^1 = 10$	$\log 10 = 1$
	$10^2 = 100$	$\log 100 = 2$
	$10^3 = 1000$	$\log 1000 = 3$ and so on.

The two parts of the logarithm of a number.

The logarithm of any number generally, consists of an integral part called *the characteristic* and a decimal part called *the mantissa*.

The integral part of the logarithm of any number can be found at once by mere inspection. Thus log 123 = 2 + a decimal, for 123 is more than 100 and less than 1,000.
Similarly log 1,234 = 3 + a decimal,

Rule. The integral part of the logarithm of a number more than 1 is one less than the number of digits in the integral part of the number.

The decimal part of the logarithm of a number cannot be found by inspection, but is given in the table of logarithms.

To read the decimal part of the logarithm of a number.

We shall consider only numbers with four figures. Let us suppose that log 1,234 is required. The procedure is as follows :—

From 12 in the 1st vertical column of Table I, proceed along the horizontal row and read the figure under 3 namely ·0899. This is the decimal part of log 123.

To obtain the decimal part of log 1234, read the difference column under 4 in the horizontal row from 12 namely 14 and add it to log 123.

Decimal part of log	123	= ·0899
Difference for	4	= 14
Decimal part of log	1,234	= ·0913

Since the integer of log 1234 is 3 (one less than the number of digits), the complete log 1,234 = 3·0913.

A shift of the decimal point in a number does not alter the decimal part of its logarithm.

$$\log 123 = 2{\cdot}0899 \quad \text{or} \quad 123 = 10^{2{\cdot}0899}$$

$$\log 12{\cdot}3 = 1{\cdot}0899 \quad \text{for} \quad 12{\cdot}3 = \frac{123}{10} = 10^{1{\cdot}0899}$$

Hence a shift of the decimal point by one place towards the left in a number decreases the integer of its logarithm by 1. But it should be noted that the decimal part of the logarithm of a number is not altered by a shift of the decimal point in the number.

The integral part of the logarithm of a decimal fraction.

	log	1·23	= 1·0899
	log	1·23	= 0·0899
—	log	·123	= $\bar{1}$·0899

Here 1 is a negative integer, the negative sign being shown over the integer.The decimal part of logarithms is always maintained positive for convenience. Hence the minus sign is written over the integer to indicate that the integer alone is negative and not the decimal part.

Again	log	·123	= $\bar{1}$·0899
∴	log	·0123	= $\bar{2}$·0899
	log	·00123	= $\bar{3}$·0899
	log	·000123	= $\bar{4}$·0899

In all these cases, the decimal part of the logarithm is the same, as the numbers have the same significant figures.

But the integer is negative and varies according to the number of ciphers between the decimal point and the first significant figure. The following rule will be useful to remember.

The integer of the logarithm of a decimal figure is negative and is one more than the number of ciphers after the decimal point and before the first significant figure.

Thus in log ·00123, the number of ciphers after the decimal point and before the first significant figure 1 is 2 and hence the integer is (2+1) = 3 and is negative. The integer is therefore entered as $\bar{3}$

$$\therefore \log \cdot 00123 = \bar{3} \cdot 0899.$$

Use of logarithms.

The great advantage of using the logarithmic tables in calculations is that it converts a multiplication into an addition and a division into a subtraction.

$$\text{Thus } \log (x \times y) = \log x + \log y$$
$$\text{and } \log (x \times y \times z) = \log x + \log y + \log z$$
$$\text{Similarly } \log x/y = \log x - \log y$$
$$\text{and } \log x/yz = \log x - \log y - \log z$$

The following examples will show how the use of the logarithms greatly simplifies multiplications and divisions.

A rectangular block has the following dimensions.

length	1·23 cms.
breadth	2·34 ,,
height	3·45 ,,

Find its volume.

Read the logarithms of 1·23, 2·34 and 3·45 from Table I.

log. 1·23	= 0·0899
,, 2·34	= 0·3692
,, 3·45	= 0·5378
Adding	0·9969

The logarithm of the product of these numbers is the sum of their logarithms = 0·9969. To obtain the product, we must find out which number has 0·9969 as its logarithm. This is given in the table of anti-logarithms. (Table II.)

Anti-logarithm of ·996		9908
Difference for	9	20
		9928

Since 0 is the integer in the logarithm, the integral part of the number must be a figure of one digit namely an integer between 1 and 10.

$$\therefore \text{ The product is } 9 \cdot 928.$$

Hence 9·928 cc. is the volume of the block correct to ·001 cc.

The degree of accuracy in the result is limited by the number of figures in the logarithms and the anti-logarithms. In ordinary calculations four figure logarithms are sufficient.

The above example illustrates the convenience of the use of logarithms in converting a multiplication into an addition, and the following example shows the use of logarithms in division.

Example :—

The mass of a body is 34·46 gms. and its volume is 21·57 cc. Calculate its density.

log 34·46 = 1·5374
log 21·57 = 1·3338
Subtracting 0·2036
Anti-logarithm of ·2036 is 1598.

The integer of the logarithm being 0, the integral part of the figure should consist of one digit.

∴ The ratio = 1·598 or 1·60 correct to the second decimal place.

Hence the density is 1·60 gms. per cc.

The use of the logarithms in simplifying multiplications and divisions at the same time is illustrated by the next example.

Example :—

Reduce the volume of 17·65 cc. of a gas measured at a temperature of 30° C. and a pressure of 765 mm. into N. T. P.

According to the gas laws, the required volume is

$$17{\cdot}65 \times \frac{273}{303} \times \frac{765}{760} \text{ cc.}$$

Enter the logarithms as follows :—

Numerator.		Denominator.	
log 17·65	1·2467	log 303	2·4814
,, 273	2·4362	,, 760	2·8808
,, 765	2·8837		
Total log	6·5666	Total log	5·3622

Subtracting the total log of the denominator ... ... 5·3622

1·2044

Anti-log of ·2044 is 1601

Since the integer is 1, the integral part of the figure is a number of two digits.

Hence the result is 16·01 cc.

To obtain the reciprocal of a number using logarithms.

Example:—

If u = 34·65 cms., find $\frac{1}{u}$

log 1 = 0·0000
log 34.65 = 1·5397
$\overline{2}$·4603

Anti-log $\overline{2}$·4603 is 2886

Since the integer of the log is $\overline{2}$, the number of ciphers ought to be 1.

Hence the reciprocal required is ·0289 correct to 4 places of decimals.

To find the value of any power of a number.

$$\log a^n = n \log a.$$

Example 1.

The length of each of the edges of a cubical block is 12·34 cms. Find its volume, The volume is $(12{\cdot}34)^3$ cc.

log 12·34 = 1·0913
3 log ,, = 3·2739

Anti-log of ·2739 is 1879.
∴ The volume is 1879 cc.

Example 2.

The volume of the receiver of an Air-pump is 700 cc. and that of the barrel 100 cc. Find the pressure after 10 strokes in terms of the initial atmospheric pressure. The final pressure, according to the formula = $(7/8)^{10}$ of the atmosphere.

To calculate $(7/8)^{10}$.

log 7 = ·8451
log 8 = ·9031
10 log 7 = 8·451
10 log 8 = 9·031
$\overline{1}$·420

Anti log ·420 = 2630

Since the integer is minus one, the fraction = ·263.

To find the mth root of any quantity.

$$\log \sqrt[m]{a} = \frac{1}{m} \log a.$$

Example 1.

The volume of a cube is 234·5cc. Find the length of each edge of the cube.

The length = $\sqrt[3]{234.5}$ cm.
log 234·5 = 2·3701
1/3 of log ,, = ·7900

Anti log of ·7900 is 6166 The length is 6·616 or 6·17 cm.

Example 2.

If the volume of a sphere is 234·5 cc., find its diameter :—

The volume of a sphere is $\frac{4\pi r^3}{3} = \frac{\pi d^3}{6} = 234{\cdot}5$

$$\frac{d^3 = 6 \times 234{\cdot}5}{\pi} \quad \text{or} \quad d = \sqrt[3]{6 \times 234{\cdot}5/\pi}$$

$3 \log d = \log 6 + \log 234{\cdot}5 - \log \pi.$

log 6 =	·7782
log 234·5 =	2·3701
	3·1483
log π	·4971
Subracting	2·6512
1/3 of 2·6512 =	·8837
Anti log ·8837 is	7.650
The diameter is	7·65 cm.

Trigonometrical ratios.

Natural sines, and tangents are given on Tables III, and IV.

To read the natural sine of any angle.

Suppose sine 39°18′ is required. Read 39 degrees in the first vertical column and go along the horizontal from 39° and read the sine of 39°10′. Read also in the same horizontal line the difference for 8′.

Sin 39° 10′	=	·6316
difference for 8′	=	18
∴ Sin 39° 18′	=	·6334

To read the natural cosine.

The cosine of any angle (less than 90°) = the sine of its complement or cos A = sin (90 − A). Suppose cos 39°18′ is required.

Cos 39°18′ = sin 50°42′, which is read from the sine table.

Note.—The sine of an angle is always a decinal fraction less than 1 except when the angle is 90°; sin 90° = 1 and sin 0° = 0. Similarly the cosine of an angle is always a decinal fraction except when the angle is 0°; cos 0° = 1 and cos 90° = 0.

To read the natural tangents.

The procedure is the same as in the case of the natural sines. Care is required in reading the integer when the angle is more than 45°; tan 0° = 0, tan 45° = 1 and tan 90° = infinity (∞).

The following examples will explain the use of logarithms in trigonometrical calculations.

Example. 1.

If the angle of minimum deviation of Sodium light in a prism is 39° 8′ and the angle of the prism 60° 12′, calculate the refractive index of the material of the prism for Sodium light.

The formula to be used is

$$\mu \text{ (Refractive index)} = \text{Sin } \frac{D+A}{2} \Big/ \text{Sin } \frac{A}{2}$$

$$D = 39° 8'$$
$$A = 60° 12'$$
$$D + A = 99° 20'$$
$$\frac{D+A}{2} = 49°40'$$
$$\frac{A}{2} = 30° 6'$$

$$\mu = \frac{\sin 49° 40'}{\sin 30° 6'}$$

$$\therefore \sin 49° 40' = \cdot 7623$$
$$\sin 30° 6' = \cdot 5015$$
$$\mu = \frac{\cdot 7623}{\cdot 5015}$$

$$\log \cdot 7623 = \bar{1} \cdot 8822$$
$$\log \cdot 5015 = \bar{1} \cdot 7002$$
$$\cdot 1820$$
$$\text{Antilog } \cdot 1820 = 1 \cdot 521$$
$$\therefore \text{ Refractive index} = 1 \cdot 521$$

Example 2.

An electric current gives a deflection of 47·5° when flowing through a coil of a Tangent galvanometer. If the coil consists of two turns of radius 7·5 cms, calculate the current. (H = ·38)

The formula is $C = \frac{10\, r\, H}{2\pi n} \tan \theta$ amperes

$$= \frac{10 \times 7 \cdot 5 \times \cdot 38}{2 \times \pi \times 2} \tan 47 \cdot 5$$

$$= \frac{75 \times \cdot 38}{4\pi} \tan 47 \cdot 5$$

Read natural tangent of 47·5° or 47° 30′

$$\tan 47° 30' = 1 \cdot 0913$$

$$C = \frac{75 \times \cdot 38 \times 1 \cdot 0913}{4 \times 3 \cdot 142}$$

log	75	=	1·8751
,,	·38	=	1·5798
,,	1·091	=	·0378
			1·4927
,,	4	=	·6021
,,	π or 3·142	=	·4971
			1·0992

1·091 alone can be read in the four figure table.

log π is used so often that it may be remembered as ·4971.

1·4927
1·0992

Subtracting ·3935
Anti log of ·3935 is 2·475
C = 2·475 amperes.

It will be observed that in the tables, the trigonometrical ratios are given only for angles up to 90°. In some cases, however, the ratios are required for angles more than 90°. The following relations can then be used

$$\sin (180 - A) = \sin A$$
$$\cos (180 - A) = -\cos A$$
$$\tan (180 - A) = -\tan A$$

Rule.

If the angle is more than 90°, subtract the angle from 180°, and then read from the tables. (In the case of the cosine and the tangent, the negative sign will have to be prefixed to the values read from the tables).

Example.

Lami's Theorem

If P, Q and R are three forces acting at a point and are in equilibrium, and A, B & C, the corresponding angles opposite to these forces, then $\frac{P}{\sin A} = \frac{Q}{\sin B} = \frac{R}{\sin C}$

Let P be 2 lbs. wt. and Q unknown, and let A and B be observed to be 135·5° and 119·5° respectively. Calculate Q.

$$\frac{Q}{\sin 119{\cdot}5^\circ} = \frac{2}{\sin 135{\cdot}5^\circ}$$

$$Q = \frac{2 \sin 119{\cdot}5^\circ}{\sin 135{\cdot}5^\circ} = \frac{2 \sin 60{\cdot}5^\circ}{\sin 44{\cdot}5^\circ} = \frac{2 \times {\cdot}8704}{{\cdot}7009}$$

log 2 = ·3010
,, ·8704 = $\bar{1}$·9397
·2407
log 7009 = $\bar{1}$·8457

Anti log ·3950 is 2·483
Q is 2·483 lbs. wt.

The ratios, cosecants, secants and cotangents of angles are not given in the tables. These are generally not required in simple calculations in Physics, but are often used in trigonometry. The following relations will enable the ratios to be readily obtained from the tables.

$$\text{cosec } A = \frac{1}{\sin A,} \quad \sec A = \frac{1}{\cos A}$$

$$\cot A = \frac{1}{\tan A,} \text{ or } \cot A = \tan (90—A)$$

Use of Reciprocals

The reciprocals of numbers 1 to 100 are given in Table VI. These are useful in practical work with spherical mirrors and lenses in Light.

If u and v are the distances of the object and its image in the case of a concave mirror, it is required to prove that $\frac{1}{u} + \frac{1}{v}$ = a constant.

Example.

If u = 54·3cms, and v = 43·2cms, calculate $1/u + 1/v$ and f of the mirror.

To obtain 1/54·3.
reciprocal of 54 = ·0185
,, 55 = ·0182
for a difference of 1 ·0003
,, ,, ·3 ·00009 or ·0001 correct to four places of decimals.

Subtracting this from the reciprocal of 54

∴ reciprocal of 54·3 = ·0184 $\left(\frac{1}{u}\right)$

Similarly to obtain 1/43·2
Reciprocal of 43 = ·0233
,, 44 = ·0227
for a difference of 1 ·0006
,, ·2 = ·00012
or = ·0001

Subtracting this from the reciprocal of 43,

reciprocal of $43{\cdot}2 = {\cdot}0232 \left(\frac{1}{v}\right)$

$\therefore \quad 1/u + 1/v = {\cdot}0184 + {\cdot}0232 = {\cdot}0416$

$1/f = {\cdot}0416$

·0417 is the reciprocal of 24

A difference of ·0001 in the reciprocal corresponds to $\frac{1}{18}$ which is less than ·1.

$\therefore \quad f = 24{\cdot}0$ cms, correct to ·1 cm.

Note.—Another method of obtaining the values of the reciprocals with the use of the logarithmic tables has already been explained.

To convert the measure of an angle from degrees into radians.

This is sometimes necessary in mathematics and higher Physics.

A radian is the angle subtended at the centre of a circle by an arc equal in length to the radius.

$$\text{One radian} = \frac{180}{\pi} = \frac{180}{3{\cdot}142} \text{radians}$$

$$= 57,^{\circ}\ 18' \text{nearly or } 57{\cdot}3^{\circ}$$

$$\text{Again } x^{\circ} = \frac{x \times \pi}{180} \text{ radians.}$$

Rule.—To convert the value of an angle from degrees into radians, multiply by $\frac{\pi}{180}$ and the product is the value in radians.

Find the value in radians of an angle of 29°.

$$\text{The value in radians} = \frac{29 \times \pi}{180}$$

$$\log 29 = 1{\cdot}4624$$

$$\log \pi = {\cdot}4971$$

$$\overline{1{\cdot}9595}$$

$$\log 180 = 2{\cdot}2553$$

$$\text{Antilog } \bar{1}{\cdot}7042 \text{ is } {\cdot}5060$$

Hence the value in radians of 29° ·5060

Some useful constants

$\pi = 3{\cdot}1416$ or $\frac{22}{7}$. The value 3·142 may be used in calculations.

$\log \pi = {\cdot}4971$.

One radian = 57·3° or 57° 18′

To convert common into Napierian logarithms, multiply by 2·3026.

SOME USEFUL CONVERSION FACTORS

Length.

1 inch = 2·54 cms.

Volume.

1 gallon = 4·54 litres.
1 pint = 20 fluid ozs = 568·2 cc.
1 fl. oz. = 28·41 cc.

Mass.

1 pound = 453·6 gms.
1 gram = 15·43 grains.

Velocity.

1 mile/hour = $\frac{22}{15}$ ft./sec.

Force.

1 pound weight = 32·2 poundals.
1 gram weight = 980 dynes.

Work.

1 joule = 10^7 ergs.
1 foot-pound = 1·360 joules.

Power. (or Rate of working)

1 Watt = 1 joule per second = 10^7 ergs per sec.
1 H. P. = 550 foot-pounds per sec. = 746 watts.

Some Simple Mensuration Formulae.

Area of triangle	=	½ base × height
,, of parallelogram	=	base × height.
,, of trapezium	=	height × ½ (sum of parallel sides).
,, of circle	=	πr^2
,, of surface of sphere	=	$4\pi r^2$
,, of curved surface of cylinder	=	$2\pi rh$
,, of curved surface of cone	=	$\pi r \times$ slant height.
Volume of cylinder	=	$\pi r^2 h$
,, sphere	=	$4\pi r^3/3$
,, cone	=	$\pi r^2 h/3$

Elasticities

Young's modulus =

$$\frac{\text{Longitdinal Force per unit area}}{\text{Elongation per unit length}} = \text{Y dynes per sq. cm.}$$

Rigidity or Torsion modulus =

$$\frac{\text{Tangential force per unit area}}{\text{Angle of shear in radians}} = n \text{ dynes per sq. cm.}$$

Volume Elasticity or Bulk modulus =

$$\frac{\text{Uniform Pressure}}{\text{Decrease in vol. per unit volume}} = \text{k dynes per sq. cm.}$$

Poisson's ratio =

$$\frac{\text{Lateral contraction per unit thickness}}{\text{Longitudinal extension per unit length}} = \sigma$$

Elastic constants for some common materials

Material	Y	*n*	*k*	σ—
Aluminium	$7{\cdot}1 \times 10^{11}$	$2{\cdot}6 \times 10^{11}$	$7{\cdot}5 \times 10^{11}$	·34
Brass	9·6 – 10·2 ,,	3·5 ,,	10·6 ,,	·35 – ·40
Copper	12·4 ,,	4·4 ,,	13·3 ,,	·34
Iron (wrought)	19 ,,	7·8 ,,	14·5 ,,	·27
,, (cast)	11 ,,	3·5—5·0 ,,	9·5 ,,	·24-30
Steel	19· – 20·5 ,,	7·8 – 8·9 ,,	17 – 19 ,,	·25 – ·32
India rubber	·05 ,,			.48

Viscosity and Surface Tension of Water

Temp. in °C	Viscosity in dynes per sq. cm.	Surface Tension in dynes per cm.
0	·0179	75·5
10	·0131	74·0
20	·0101	72·5
30	·0080	71·0
40	·0066	69·5

Note.—The viscosity of water decreases rapidly with the temperature. The surface tension decreases almost uniformly at the rate of ·15 dyne per cm. per °C.

MOMENTS OF INERTIA

M = mass of body.

Shape of body.	Axis.	Moment of Inertia
Thin Uniform rod (length l)	Through centre, perpendicular to length	$\frac{M l^2}{12}$
,,	Throngh end, perpendicular to length	$\frac{M l^2}{3}$
Rectangular lamina or plate (sides a & b)	Through C. G., perpendicular to plane	$M\frac{a^2 + b^2}{12}$
,,	Through C.G., parallel to side a	$\frac{M b^2}{12}$
Circular lamina or plate (radius. r)	Through centre, perpendicular to plane	$\frac{M r^2}{2}$
,,	Any diameter	$\frac{M r^2}{4}$
Annular disc (outer radius R & inner r)	Through centre, perpendicular to plane	$\frac{M (R^2 + r^2)}{2}$
,,	Any diameter	$\frac{M (R^2 + r^2)}{4}$
Cylinder-solid (length l, radius r)	Through C. G., perpendicular to length	$M\left(\frac{l^2}{12} + \frac{r^2}{4}\right)$
,,	Axis of cylinder	$\frac{M r^2}{2}$
Cylinder-hollow. length l, External radius R, Internal radius r	Through C. G., perpendicular to length	$M\left(\frac{l^2}{12} + \frac{R^2 + r^2}{4}\right)$
,,	Axis of cylinder	$M\left(\frac{R^2 + r^2}{2}\right)$
Sphere, solid radius r	Any diameter	$M\left(\frac{2 r^2}{5}\right)$

HEAT

Temperature:—Conversion from Centigrade into Fahrenheit scale and vice-versa.

If C represents the temperature in degrees Centigrade and F, the same temperature in degrees Fahrenheit, then

$$\frac{C}{100} = \frac{F - 32}{180}$$

Coefficient of Expansion.

The *coefficient* of *linear expansion* of a solid is the increase in length per unit length due to a rise of temperature of 1°C and is denoted by a

The coefficient of surface expansion of solids = $2a$
" cubical " " = $3a$

The coefficient of cubical expansion of a liquid (γ) *is the* increase in volume per °C of unit volume at 0°C.

The coefficient of absolute expansion of a liquid (γ = the coefficient of apparent expansion of the liquid in a vessal + the coefficient of cubical expansion of the material of the vessel.

Solids	a	Liquids	γ
Aluminium	$\cdot 25 \times 10^{-4}$	Water (10° to 50°C) mean	$\cdot 30 \times 10^{-3}$
Brass	·19 "	Mercury	·18 "
Copper	·167 "	Oil-Olive	·72 "
Glass	·089 "	— Paraffin	·95 "
Iron	·117 "	— Cocoanut	·75 "
Lead	·28 "	Turpentine	·94 "
Platinum (same as for glass)	·090 "	Glycerine	·50 "
Silver	·19 "		
Tin	·21 "		
Zinc	·26 "		

Gases.—Coefficient of cubical expansion of a gas at constant pressure.

i.e., (increase of volume per °C/ volume at O°C) = $\frac{1}{273}$ = ·00366.

Also Coefficient of pressure at constant volume,

i.e., (increase of pressure per °C/ pressure at O°C) = $\frac{1}{273}$ = ·00366.

Specific Heats of some common substances

The Specific heat of a substance = the ratio of the heat required to raise a mass of the substance 1°C to the quantity of heat required to raise an equal mass of water 1°C.

Elements		*Other substances*	
Material	Sp. ht.	Material	Sp. ht.
Aluminium	·22	Brass	·090
Copper	·094	Glass	·15
Iron	·12	India rubber	·3 to ·5
Lead	·031	Ice	·50
Mercury	·033	Sand	·20
Silver	·056	*Liquids*	
Tin	·055	Alcohol	·56
Zinc	·090	Glycerine	·60
		Oil. Olive	·48
		,, Paraffin	·50 to ·55
		,, Cocoanut	·5
		Turpentine	·4

A calorie is the quantity of heat required to raise 1 gm. of water through 1°C. It is the unit quantity of heat commonly used in Physics.

Latent Heat

Latent Heat. The Latent heat of fusion of a substance is the quantity of heat required to convert 1 gm. of solid into 1 gm. of liquid without change of temperature.

Latent heat of Fusion of ice = 79·6 calories per gm.

The Latent heat of vaporisation of a liquid is the quantity of heat required to convert 1 gm. of liquid into 1 gm. of vapour without change of temperature.

Latent heat of vaporisation of water (or latent heat of steam) at 100°C = 537 calories per gm.

Latent Heat at t°C (Lt.) = 606·5—·695t (Regnault).

Thermal Conductivity

The thermal conductivity (k) is the quantity of heat in calories conducted per sq. cm. in 1 sec. across a slab of the

material of thickness 1 cm., when a difference of temperature of 1°C is maintained between opposite faces.

Metals. Good Conductors.		Poor Conductors.	
Material	Conductivity k^*	Material	Conductivity k^*
Aluminium	·50	Glass	$\cdot 3 \times 10^{-3}$
Brass	·25	Wood	·5 ,,
Iron	·12	Cardboard	·4 ,,
Lead	·08	Asbestos	·5 ,,
Silver	·98	India rubber	·4 ,,
Tin	·16	Cork	·1 ,,
Zinc	·27	Cotton	·5 ,,
		Flannel	·2 ,,

* Approximate values.

Saturation Vapour Pressure of Water

Temp. °C	m.m.	Temp. °C	m.m.	Temp. °C	m.m.	Temp. °C	Atmos.
—5	3·1	21	18·5	70	233·1	100	1
—4	3·4	22	19·7	75	288·5	105	1·2
—3	3·7	23	20·9	80	354·6	110	1·4
—2	4·0	24	22·2	85	433·0	120	1·96
—1	4·3	25	23·6	90	525·4	140	3·6
0	4·6	26	25·0	91	545·8	160	6·1
1	4·9	27	26·5	92	566·7	180	9·9
2	5·3	28	28·1	93	588·3	200	15·4
3	5·7	29	29·8	94	610·6	220	22·9
4	6·1	30	31·6	95	633·7		
5	6·5	31	33·5	96	657·4		
6	7·0	32	35·5	97	681·9		
7	7·5	33	37·6	98	707·1		
8	8·0	34	39·8	99	733·2		
9	8·6	35	42·0	100	760·0		
10	9·2	36	44·4	101	784·9		
11	9·8	37	46·9	102	815·9		
12	10·5	38	49·5				
13	11·2	39	52·3				
14	11·9	40	55·1				
15	12·7	45	71·4				
16	13·5	50	92·0				
17	14·4	55	117·5				
18	15·4	60	148·8				
19	16·4	65	186·9				
20	17·4						

Note.—The boiling points of water at various barometric pressures can be obtained from the vapour pressure tables, for the vapour pressure of a liquid at the temperature of the boiling point = the external pressure to which the liquid surface is subject.

Wet and Dry bulb Hygrometer

The table gives the factor by which the difference in readings of the Wet and Dry bulb thermometers should be multiplied to obtain the difference between the Dew point and the reading of the Dry bulb thermometer. The factor varies with the dry bulb reading, and decreases as the reading rises

(Adapted from Glaisher's tables).

Dry bulb reading °C	Factor	Dry bulb reading °C	Factor
10	2·06	26	1·69
11	2·02	27	1·68
12	1·99	28	1·67
13	1·95	29	1·66
14	1·92	30	1·65
15	1.89	31	1·64
16	1·87	32	1·63
17	1·85	33	1·62
18	1·83	34	1·61
19	1·81	35	1·60
20	1·79		
21	1·77		
22	1·75		
23	1·74		
24	1·72		
25	1·70		

SOUND

Velocity of Sound

The velocity of sound (V) in any gas = $\sqrt{rP/d}$, where d is the density and P the pressure of the gas and r the ratio of the specific heat of the gas at constant pressure to that at constant volume ; r may be taken to be 1·4 for air and the common gases.

The velocity of sound in air at O°C = 331· 3 metres per sec.
or 1087 feet per sec.

and the velocity decreases with the temperature according to the formula $V/V_o = \sqrt{T/T_o}$ where T and T_o are the absolute temperatures and V and V_o the corresponding velocities.

In the case of air, the following simple formula can be used to readily obtain the velocities at different temperatures.

$V_t = 331{\cdot}3 + {\cdot}61\ t$ metres per sec.
or $1087 + 2\ t$ feet per sec.

The increase in the velocity of sound in air due to a rise of temperature of 1°C is ·61 metres (61 cms.) per sec. or 2 ft. per sec.

Velocity of sound in water = 1450 metres per sec.

Solids	Velocity of sound in metres per sec.
Aluminium	5100
Brass	3650
Copper	3970
Iron	4500 to 5100
Wood	4500
Glass	5200

*Approximate values (useful in Kundt's tube experiments).

Musical Scale

	C	D	E	F	G	A	B	C^1
European notation	Do	Re	Mi	Fa	Sol	La	Si	Do
Indian ,,	Sah	Rhee	Gha	Mah	Pah	Dha	Nee	Sah
Relative numbers	24	27	30	32	36	40	45	48
Ratios	1	9/8	5/4	4/3	3/2	5/3	15/8	2
Standard frequency	256	288	320	341·3	384	426·7	480	512
Prominent musical intervals	funda-mental		Third		Fifth			Octave

The Velocity of sound in a gas is the same for all notes. But the wave length varies; $V = n \lambda$, where n is the frequency and λ the wave length of the note.

The frequency of a vibrating wire. is given by

$n = \frac{1}{2l}\sqrt{T/m}$ where T is the tension in dynes, m the mass per unit length, and l the length of the wire.

Relation between the frequency (n) of a note and the length l of a resounding air-column

$$V = 4n(l + \cdot 6r)$$

r being the radius of the tube enclosing the air column which is closed at one end.

End correction for an open pipe = ·6 radius

Light

Velocity of Light in air = 186000 miles per sec.
or $3{\cdot}00 \times 10^{10}$ cms. per sec.

Refractive index $\mu = \frac{\sin i}{\sin r}$ where i is the angle of incidence in air and r the angle of refraction in the medium.

$\mu = 1$ (Vacuum and air).

Liquids	μ	Solids	μ
Water	1·33	Glass. Crown	1·52
Alcohol	1·35		
Aniline	1·59	,, Flint Dense	1·60 to 1·68
Benzene	1·50	to Extra-Dense	
Chloroform	1·45	Alum	1·46
Ether	1·36	Canada-balsam	1·54
Glycerine	1·47	Diamond	2·42
Oil-Paraffin	1·44	Ice	1·31
,, Olive	1·45	Rock salt	1·54
Turpentine	1·47		

Wavelengths of the prominent Fraunhofer lines

Region of the Spectrum.	Name of line.	Wavelength in A. u	Element in the solar atmosphere.
Red	A	7594	—
,,	a	7186	—
,,	B	6867	—
,,	C	6563	Hydrogen
Yellow	D_1	5896	Sodium
,,	D_2	5890	,,
Green	E	5270	Iron
,,	b_2 (middle)	5173	Magnesium
Blue	F	4861	Hydrogen
Violet	G	4308	Iron

1. A. u (Angstrom Unit $= 10^{-10}$ metre or 10^{-8} cm).

Some Useful formulae

Refraction from a denser medium into air $\mu = \frac{\text{Depth of object}}{\text{Depth of image.}}$

Critical angle $\propto$

$$\text{Sin } \propto = \frac{1}{\mu}$$

Prism

$r + r_1 = A$ (1) A = angle of prism.

$i + i_1 - A = D$ (2) D = deviation of a ray

where r and r_1 are the angles made by the ray within the prism with the normals and i and i_1 the angles of incidence and emergence

$$\mu = \text{Sin } \frac{D+A}{2} \Big/ \text{Sin } A_{/2}$$

D = angle of minimum deviation.

Minimum angle of incidence (i) *on a prism for emergence to be possible*

$$\frac{\sin i}{\sin (A - \propto)} = \mu$$

$\propto$ = critical angle

A = angle of prism (usually 60°).

Spherical mirrors

Concave $\frac{1}{u} + \frac{1}{v} = \frac{2}{r}$ (real images)

" $\frac{1}{u} - \frac{1}{v} = \frac{2}{r}$ (virtual images)

u distance of object, v distance of image from the mirror, and r radius of curvature of the mirror

Convex $\frac{1}{u} - \frac{1}{v} = -\frac{2}{r}$ (image always virtual and diminished)

Lenses

Concave $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ (image always virtual and diminished)

Convex $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ (real images)

" $\frac{1}{v} - \frac{1}{u} = -\frac{1}{f}$ (virtual images)

u and v are the distances of the object and its image from the lens and f, the focal length of the lens.

Magnification in lenses and mirrors $= \frac{v}{u}$

Note. In the formulae for lenses and mirrors, u, v, r and f represent merely the numerical magnitudes of the distances. The signs have been allowed for in the formulae.

Simple Microscope

$\frac{1}{D} - \frac{1}{u} = \frac{-1}{f}$. (D is the least distance of distinct vision.)

Magnifying power $= 1 + D/f$

Telescope

Astronomical. Distance between object glass and eyepiece $= F + f$ (both convex)

F = focal length of object glass

f = ...eyepiece. Galileo's. Distance $= F - f$

(The eyepiece is here concave)

Magnifying power in both cases $= F/f$.

MAGNETISM

Some useful formulae.

Inverse square law.

$F = \frac{mm'}{r^2}$ where m and m' are the strengths of the two poles at a distance r apart and F the force between them.

Magnetic force due to a magnet at a point.

A :—*End – on – position*

$F = 2\ M/r^3$ (short magnet – r large)

$F = \frac{2\ Mr}{(r^2 - l^2)^2}$, where the length of the magent $(2l)$ is not negligible. (M.—magnetic moment of magnet r – distance from point to centre of magnet)

B :— *Broadside-on position*

$F = \frac{M}{r^3}$ (short magnet – r large)

$F = \frac{M}{(r^2 + l^2)^{3/2}}$ where the length of the magnet is not negligible.

Relation between F and H in deflection experiments.

$F = H \tan \theta$, when F is the force in the end – on or the broad side – on position as the case may be.

Period of oscillation of a magnet

$T = 2\pi\sqrt{\frac{K}{MH}}$ where K is a constant, (termed moment of inertia) for the given magnet, M the magnetic moment of the magnet and H, the intensity of the magnetic field, in which the magnet swings.

$M H = 4\ \pi^2\ n^2\ K$

or H is proportional to n^2, n being the number of oscillations made by the magnet in a given time. This relation is useful in vibration experiments.

Values of H and Dip.

	H.	Dip or Inclination.
Greenwich	·18	67° North
Bombay	·37	20° ,,
Madras	·38	13° ,,

Earth's Total Intensity and its components.

$H = I\cos i$
$V = I\sin i$

I total Intensity, i dip H and V – horizontal and vertical components of the total Intensity.

Current Electricity.

Practical units.

The Ampere.

The practical unit of current (The ampere) = $\frac{1}{10}$ of the C. G. S. unit of current. and the C. G. S. unit current is that current which when flowing along an arc of a circle of length 1 cm. and radius 1 cm. produces at the centre a magnetic force of 1 dyne on unit pole.

The Ampere may also be remembered as the current that deposits ·001118 gm. of Silver in 1 second.

The Volt.

The practical unit of Electromotive force is the difference of potential in which a current of 1 ampere flowing for 1 second does a work of 1 joule or liberates $^1/_{4\cdot2}$ calorie of heat.

The Ohm

The unit of Electrical resistance is the resistance of a conductor in which a potential difference of 1 volt between the ends causes a current of 1 ampere to flow through it.

Relation between Practical and C. G. S. units.

	Practical unit	
Current	Ampere	$= \frac{1}{10}$ C. G. S. unit.
E. M. F.	Volt	$= 10^8$,,
Resistance	Ohm	$= 10^9$,,
Quantity of electri city	Coulomb	$= \frac{1}{10}$,,
Capacity	Farad	$= \frac{1}{10^9}$,,
Work	Joule	$= 10^7$ ergs.
Power	Watt	$= 10^7$ ergs per sec.
Inductance	Henry	$= 10^9$ C. G. S. units.

1 H. P. = 746 Watts

H. P. absorbed by an Electric motor = $\frac{\text{Wattage}}{746}$

Wattage = Voltage × Amperage.

The unit quantity of Electrical energy in commercial use is the Kilo-watt hour, termed K. W. H. and stated also as the Board of Trade Unit (B. T. U.). It is the energy consumed when 1000 watts are expended in a circuit for an hour.

Primary cells

	E. M. F. volts	Internal resistance Ohms * (approximate)	Materials used
Daniell	1·08	1	Zinc, dil. sulphuric acid 1 of acid to 10 of water), saturated sol. of Cu SO_4 and Cu.
Leclanche	1·5	1	Zinc, saturated sol. of ammonium chloride, coke carbon.
Dry	1·5	·5	(Same as above, but solution in the form of a paste)
Grove and Bunsen	1·93	·2	Zinc, dil. sulphuric acid (1 to 10) conc. Nitric acid and platinum or carbon.
Bichromate	1·96	very low	Zinc, 1 part Bichromate 2 parts sulphuric acid strong, and 12 parts water (by weight) and carbon.

* *Note.* The internal resistance of a cell varies widely with the size of the cell and the materials used. The above values are to be taken as very approximate.

Secondary cells

	E. M. F. volts	Internal resistance ohm.
Lead. Accumulator (sulphuric acid)	2·0 to 2·2	negligible
Edison-Alkali,	1·2	·0 2 ohm.

Standard cells.

Clark cell.

E. M. F. at 15° C = 1·4328 volt.

E. M. F. at $t°$ C = $1{\cdot}4328 - 11{\cdot}9\,(t - 15)\,{\cdot}10^{-4}$

Cadmium cell

E. M. F. at 20° C = 1·0186 volt.

E. M. F. at t° C = $1{\cdot}0186 - 38{\cdot}0\,(t - 20)\,{\cdot}10^{-6}$

The E. M. F's of the cells at a few different temperatures are given below.

Temp.	Clark.	Cadmium
15° C	1·4328 volts	1·0188 volts
20° C	1·4267	1·0186
25° C	1·4200	1·0184
30° C	1·4134	1·0182

Some useful formulae

Magnetic effects of Electric currents.

Magnetic force at the centre of a circular coil carrying a current $= \frac{2\pi n C}{r}$ (*C.* currrent in C. G. S. units)

$= \frac{2\pi n A}{10 r}$ (*A.* current in amperes)

Current in a Tangent Galvanometer. $= \frac{10 r H}{2\pi n} \tan \theta$

(r, radius and n, no. of turns of coil, θ deflection)

$\frac{10 r H}{2\pi n}$ is termed reduction factor and is denoted by k.)

Ohm's Law

$$\frac{E}{C} = R, \text{ or } \frac{E}{R} = C, \text{ or } E = CR$$

E. potential difference, C, current, R, resistance.

A complete circuit including a battery

$\frac{\mathfrak{E}}{B+R} = C$ (B. Internal resistance R. External resistance)

Resistance of a parallel combination of resistances. (R_1 and R_2)

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

Distribution of current among two conductors in parallel,

$$C_1 = \frac{C. R_2}{R_1 + R_2} \quad \text{and} \quad C_2 = \frac{C. R_1}{R_1 + R_2}$$

(C_1 and C_2 currents in the resistances R_1 and R_2.)

Current in a galvanometer provided with a shunt

$$C_g = \frac{C. S}{S + G.}$$

S resistance of shunt, G resistance of galvanometer, and C total current.

Heating effects of electric currents.

Joule's law.

$$H = \frac{ECt}{4{\cdot}2} = \frac{RC^2t}{4{\cdot}2},$$ where H is expressed in calories, R in ohms, E in volts, C in amperes and t in seconds.

Chemical effects of electric currents

$$m = e\,C\,t$$

(m mass of ion or element liberated by a current of C amperes in time t seconds, and e the electro-chemical equivalent.)

The electro-chemical equivalent of an element or ion is the quantity of it that is liberated by a current of one ampere flowing for one second or by a quantity of electricity of one coulomb.

A coulomb is the quantity of electricity that passes when a current of one ampere flows for one second.

Element	Electro-chemical equivalent grm. per coulomb
Copper	·0003294
Silver	·001118
Hydrogen	·0000104

The electro-chemical equivalents of other elements can be obtained by using Faraday's second law of electrolysis (namely); the electro-chemical equivalents of different elements are proportional to their chemical equivalents.

(It is useful to remember that a current of 1 ampere liberates in 1 minute nearly 7 cc of Hydrogen or 10·5 cc of mixed gases (Hydrogen and Oxygen) at N. T. P.

Specific Resistance.

The resistance of a length of a wire is given by the following formula. $R = s.\frac{l}{a}$ where l is the length of the wire in cms, a the area of section in sq. cms, and s, a constant for the material of the wire termed *specific resistance*. The *specific resistance* of a material is the resistance between opposite faces of a unit cube of the material.

Change of resistance with temperature.

$$R_t = R_O\ (1 + at).$$

where Rt and Ro are the resistances of a wire at $t°c$ and $o°c$ respectively, and a is a constant for the material of the wire (termed temperature coefficient of resistance)

Material	Specific resistance	Temperature coefficient
	-6	-4
Aluminium	3·1 × 10	41 × 10
Copper	1·78 ,,	40 ,,
Iron	12 to 14 ,,	55 ,,
Steel	19 ,,	15 to 40 ,,
Mercury	95 ,,	8 ,,
Platinum	11·0 ,,	36 ,,
Silver	1·63 ,,	39 ,,
Zinc	6·1 ,,	36 ,,
Alloys		
Brass	6 to 9 ,,	11 ,,
Constantan	46 ,,	Varying and negligible
German silver	26 ,,	2·4 ,,

Standard Wire-Gauge and Resistances in Ohms per metre of wire

(ADAPTED FROM SPON'S ELECTRICAL POCKET BOOK)

Size.	Diameter mm.	Copper (annealed).	German silver.	English Manganin.	Eureka or Constantan.
12	2·64	·0031	·041	·075	·086
14	2·03	·0052	·069	·126	·145
16	1·63	·0082	·108	·196	·228
18	1·22	·0145	·192	350	·400
20	·914	.0258	·343	·62	·720
22	·711	·0427	·566	1·04	1·19
24	·559	·0692	·92	1·68	1·93
26	·457	·103	1·37	2·50	2·88
28	·376	·153	2·02	3·81	4·26
30	·315	·218	2.89	5·24	6·07
32	·274	·287	3.81	6·90	8·03
34	·234	·395	5·26	9·60	11·0
36	·193	·580	7·70	14·1	16·2

Arrangement of cells to form a battery :

Expression for the current :—Cells in series. Let n be the number of cells, E the E.M.F., and B the internal resistance of each cell, and R the external resistance.

$$C = \frac{n\,E}{n\,B + R}$$

Cells in parallel. Let m be the number of cells.

$$C = \frac{E}{B/m + R}$$

Combined series and parallel arrangement. Let N be the total number of cells arranged in m rows of n cells in series.

$$C = \frac{n\,E}{n\,B/m + R} = \frac{N\,E}{n\,B + m\,R}$$

The current is maximum when $\frac{n\,B}{m} = R$ *i.e.*, when the total internal resistance of the battery = the external resistance.

For maximum Current, $n = \sqrt{NR/B}$ and $m = \sqrt{NB/R}$.

E. M. F. on open and closed circuit :—

Let E be the E. M. F. of a battery on open circuit, B the internal resistance of the battery and C the current when the external resistance is R.

$$E = C\,(B + R)$$

The E. M. F. on closed circuit (e), is given by the relation.

$$e = CR$$

Hence, fall of potential on closed circuit = CB.

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INTERNATIONAL ATOMIC WEIGHTS (1930) AND THE VALENCIES OF THE CHIEF ELEMENTS

Element.	Symbol	Atomic weight O = 16	Valency	Element.	Symbol	Atomic weight O = 16	Valency
Aluminium	Al	26·97	3	Mercury	Hg	200·61	1, 2
Antimony	Sb	121·77	3, 5	Molybdenum	Mo	96·0	3, 6
Argon	A	39·94	0	Neodymium	Nd	144.27	--
Arsenic	As	74·96	3, 5	Neon	Ne	20·183	0
Barium	Ba	137·36	2	Nickel	Ni	58·69	2, 3
Beryllium	Be	9·02	2	Nitrogen	N	14·008	3, 5
Bismuth	Bi	209·00	3, 5	Osmium	Os	190·8	8
Boron	B	10·82	3	Oxygen	O	16·000	2
Bromine	Br	79·916	1	Palladium	Pd	106·7	--
Cadmium	Cd	112·41	2	Phosphorus	P	31·02	3, 5
Caesium	Cs	132·81	1	Platinum	Pt	195·23	2, 4
Calcium	Ca	40·07	2	Potassium	K	39·10	1
Carbon	C	12·001	2, 4	Praseodymium	Pr	140·92	--
Cerium	Ce	140·13	--	Radium	Ra	225·97	2
Chlorine	Cl	35·457	1	Rhenium	Re	188·7	--
Chromium	Cr	52.01	3, 6	Radon	Rn	222·0	--
Cobalt	Co	58·94	2, 3	Rhodium	Rh	102·91	--
Columbium	Cb	93·1	--	Rubidium	Rb	85·44	1
Copper	Cu	63·57	1, 2	Ruthenium	Ru	101·7	8
Dysprosium	Dy	162·46	--	Samarium	Sm	150·43	--
Erbium	Er	167·64	--	Scandium	Sc	45·10	3
Europium	Eu	152·0	--	Selenium	Se	79·2	2
Fluorine	F	19·00	1	Silicon	Si	28·06	4
Gadolinium	Gd	157·26	--	Silver	Ag	107·880	1
Gallium	Ga	69·72	2	Sodium	Na	22·997	1
Germanium	Ge	72·60	4	Strontium	Sr	87·63	2
Gold	Au	197·2	1, 3	Sulphur	S	32·06	2,4,6
Hafnium	Hf	178·6	--	Tantalum	Ta	181·5	--
Helium	He	4·002	0	Tellurium	Te	127·5	2
Holmium	Ho	163·5	--	Terbium	Tb	159·2	--
Hydrogen	H	1·0078	1	Thallium	Tl	204·39	1
Indium	In	114·8	2, 3	Thorium	Th	232·12	4
Iodine	I	126·932	1	Thulium	Tm	169·4	--
Iridium	Ir	193·1	3	Tin	Sn	118·70	2, 4
Iron	Fe	55·84	2, 3	Titanium	Ti	47·90	4
Krypton	Kr	82·9	0	Tungsten	W	184·0	6
Lanthanum	La	138·90	3	Uranium	U	238·14	6
Lead	Pb	207·22	2, 4	Vanadium	V	50·96	--
Lithium	Li	6·940	1	Xenon	Xe	130·2	0
Lutecium	Lu	175·0	--	Ytterbium	Yb	173·6	--
Magnesium	Mg	24·32	2	Yttrium	Y	88·92	--
Manganese	Mn	54·93	2, 3 4, 7	Zinc	Zn	65·38	2
				Zirconium	Zr	91·22	--

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TABLES

Table I.
LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Differences.								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

Table I.
LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Differences.								
											1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

Table II.

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Differences. 1	2	3	4	5	6	7	8	9
·00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
·01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
·02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
·03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
·04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
·05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
·06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
·07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	3
·08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
·09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
·10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
·11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
·12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
·13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
·14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
·15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
·16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
·17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
·18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
·19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
·20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
·21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
·22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
·23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
·24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
·25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
·26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
·27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
·28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
·29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
·30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
·31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
·32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
·33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
·34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
·35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
·36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
·37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
·38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
·39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
·40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
·41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
·42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
·43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
·44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
·45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
·46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
·47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
·48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
·49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

Table II
ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Differences.								
											1	2	3	4	5	6	7	8	9
00	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
01	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
02	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
03	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
04	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
05	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
06	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
07	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
08	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
09	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
10	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
11	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
12	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
13	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
14	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
15	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
16	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
17	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
18	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
19	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
20	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
21	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
22	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
23	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
24	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	[illegible]	9	10	12
25	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
26	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
27	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
28	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
29	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
30	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
31	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
32	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
33	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
34	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
35	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
36	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
37	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
38	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
39	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
40	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
41	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
42	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
43	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
44	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
45	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
46	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
47	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
48	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
49	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

Table III

NATURAL SINES

	0′	10′	20′	30′	40′	50′	Differences. 1′	2′	3′	4′	5′	6′	7′	8′	9′
0°	·0000	·0029	·0058	·0087	·0116	·0145	3	6	9	12	15	17	20	23	26
1	·0175	·0204	·0233	·0262	·0291	·0320	3	6	9	12	15	17	20	23	26
2	·0349	·0378	·0407	·0436	·0465	·0494	3	6	9	12	15	17	20	23	26
3	·0523	·0552	·0581	·0610	·0640	·0669	3	6	9	12	15	17	20	23	26
4	·0698	·0727	·0756	·0785	·0814	·0843	3	6	9	12	14	17	20	23	26
5	·0872	·0901	·0929	·0958	·0987	·1016	3	6	9	12	14	17	20	23	26
6	·1045	·1074	·1103	·1132	·1161	·1190	3	6	9	12	14	17	20	23	26
7	·1219	·1248	·1276	·1305	·1334	·1363	3	6	9	12	14	17	20	23	26
8	·1392	·1421	·1449	·1478	·1507	·1536	3	6	9	12	14	17	20	23	26
9	·1564	·1593	·1622	·1650	·1679	·1708	3	6	9	12	14	17	20	23	26
10	·1736	·1765	·1794	·1822	·1851	·1880	3	6	9	12	14	17	20	23	26
11	·1908	·1937	·1965	·1994	·2022	·2051	3	6	9	11	14	17	20	23	26
12	·2079	·2108	·2136	·2164	·2193	·2221	3	6	9	11	14	17	20	23	26
13	·2250	·2278	·2306	·2334	·2363	·2391	3	6	8	11	14	17	20	23	25
14	·2419	·2447	·2476	·2504	·2532	·2560	3	6	8	11	14	17	20	23	25
15	·2588	·2616	·2644	·2672	·2700	·2728	3	6	8	11	14	17	20	22	25
16	·2756	·2784	·2812	·2840	·2868	·2896	3	6	8	11	14	17	20	22	25
17	·2924	·2952	·2979	·3007	·3035	·3062	3	6	8	11	14	17	19	22	25
18	·3090	·3118	·3145	·3173	·3201	·3228	3	6	8	11	14	17	19	22	25
19	·3256	·3283	·3311	·3338	·3365	·3393	3	5	8	11	14	16	19	22	25
20	·3420	·3448	·3475	·3502	·3529	·3557	3	5	8	11	14	16	19	22	25
21	·3584	·3611	·3638	·3665	·3692	·3719	3	5	8	11	14	16	19	22	24
22	·3746	·3773	·3800	·3827	·3854	·3881	3	5	8	11	14	16	19	21	24
23	·3907	·3934	·3961	·3987	·4014	·4041	3	5	8	11	13	16	19	21	24
24	·4067	·4094	·4120	·4147	·4173	·4200	3	5	8	11	13	16	19	21	24
25	·4226	·4253	·4279	·4305	·4331	·4358	3	5	8	11	13	16	18	21	24
26	·4384	·4410	·4436	·4462	·4488	·4514	3	5	8	10	13	16	18	21	23
27	·4540	·4566	·4592	·4617	·4643	·4669	3	5	8	10	13	16	18	21	23
28	·4695	·4720	·4746	·4772	·4797	4823	3	5	8	10	13	15	18	20	23
29	·4848	·4874	·4899	·4924	·4950	·4975	3	5	8	10	13	15	18	20	23
30	·5000	·5025	·5050	·5075	·5100	·5125	3	5	8	10	13	15	18	20	23
31	·5150	·5175	·5200	·5225	·5250	·5275	2	5	7	10	12	15	17	20	22
32	·5299	·5324	·5348	·5373	·5398	·5422	2	5	7	10	12	15	17	20	22
33	·5446	·5471	·5495	·5519	·5544	·5568	2	5	7	10	12	15	17	19	22
34	·5592	·5616	5640	·5664	·5688	·5712	2	5	7	10	12	14	17	19	22
35	·5736	·5760	·5783	·5807	·5831	·5854	2	5	7	10	12	14	17	19	21
36	·5878	·5901	·5925	·5948	·5972	·5995	2	5	7	9	12	14	16	19	21
37	·6018	·6041	·6065	·6088	·6111	·6134	2	5	7	9	12	14	16	18	21
38	·6157	·6180	·6202	·6225	·6248	·6271	2	5	7	9	11	14	16	18	20
39	·6293	·6316	·6338	·6361	·6383	·6406	2	4	7	9	11	14	16	18	20
40	6428	·6450	·6472	·6494	·6517	·6539	2	4	7	9	11	13	15	18	20
41	6561	·6583	·6604	·6626	·6648	·6670	2	4	7	9	11	13	15	17	20
42	·6691	·6713	·6734	·6756	·6777	·6799	2	4	6	9	11	13	15	17	19
43	·6820	·6841	·6862	·6884	·6905	·6926	2	4	6	8	11	13	15	17	19
44	·6947	·6967	·6988	·7009	·7030	·7050	2	4	6	8	10	12	15	17	19
	0′	10′	20′	30′	40′	50′	1′	2′	3′	4′	5′	6′	7′	8′	9′

NATURAL SINES

	0′	10′	20′	30′	40′	50′	Mean Differences.								
							1′	2′	3′	4′	5′	6′	7′	8′	9′
45°	·7071	·7092	·7112	·7133	·7153	·7173	2	4	6	8	10	12	14	16	18
46	·7193	·7214	·7234	·7254	·7274	·7294	2	4	6	8	10	12	14	16	18
47	·7314	·7333	·7353	·7373	·7392	·7412	2	4	6	8	10	12	14	16	18
48	·7431	·7451	·7470	·7490	·7509	·7528	2	4	6	8	10	12	14	15	17
49	·7547	·7566	·7585	·7604	·7623	·7642	2	4	6	8	10	11	13	15	17
50	·7660	·7679	·7698	·7716	·7735	·7753	2	4	6	7	9	11	13	15	17
51	·7772	·7790	·7808	·7826	·7844	·7862	2	4	5	7	9	11	13	15	16
52	·7880	·7898	·7916	·7934	·7951	·7969	2	4	5	7	9	11	12	14	16
53	·7986	·8004	·8021	·8039	·8056	·8073	2	4	5	7	9	10	12	14	16
54	·8090	·8107	·8124	·8141	·8158	·8175	2	3	5	7	9	10	12	14	15
55	·8192	·8208	·8225	·8241	·8258	·8274	2	3	5	7	8	10	12	13	15
56	·8290	·8307	·8323	·8339	·8355	·8371	2	3	5	6	8	10	11	13	14
57	·8387	·8403	·8418	·8434	·8450	·8465	2	3	5	6	8	9	11	13	14
58	·8481	·8496	·8511	·8526	·8542	·8557	2	3	5	6	8	9	11	12	14
59	·8572	·8587	·8602	·8616	·8631	·8646	2	3	4	6	7	9	10	12	13
60	·8660	·8675	·8689	·8704	·8718	·8732	1	3	4	6	7	9	10	11	13
61	·8746	·8760	·8774	·8788	·8802	·8816	1	3	4	6	7	8	10	11	13
62	·8830	·8843	·8857	·8870	·8884	·8897	1	3	4	5	7	8	9	11	12
63	·8910	·8923	·8936	·8949	·8962	·8975	1	3	4	5	7	8	9	10	12
64	·8988	·9001	·9013	·9026	·9038	·9051	1	3	4	5	6	8	9	10	11
65	·9063	·9075	·9088	·9100	·9112	·9124	1	2	4	5	6	7	8	10	11
66	·9136	·9147	·9159	·9171	·9182	·9194	1	2	4	5	6	7	8	9	10
67	·9205	·9216	·9228	·9239	·9250	·9261	1	2	3	5	6	7	8	9	10
68	·9272	·9283	·9294	·9304	·9315	·9325	1	2	3	4	5	6	8	9	10
69	·9336	·9346	·9357	·9367	·9377	·9387	1	2	3	4	5	6	7	8	9
70	·9397	·9407	·9417	·9426	·9436	·9446	1	2	3	4	5	6	7	8	9
71	·9455	·9465	·9474	·9483	·9492	·9502	1	2	3	4	5	6	6	7	8
72	·9511	·9520	·9528	·9537	·9546	·9555	1	2	3	4	4	5	6	7	8
73	·9563	·9572	9580	·9588	·9596	·9605	1	2	3	3	4	5	6	7	7
74	·9613	·9621	·9629	·9636	·9644	·9652	1	2	2	3	4	5	5	6	7
75	·9659	·9667	·9674	·9682	·9689	·9696	1	2	2	3	4	4	5	6	7
76	·9703	·9710	·9717	·9724	·9730	·9737	1	1	2	3	3	4	5	5	6
77	·9744	·9750	·9757	·9763	·9769	·9775	1	1	2	3	3	4	4	5	6
78	·9782	·9788	·9793	·9799	·9805	·9811	1	1	2	2	3	4	4	5	5
79	·9814	·9822	·9827	·9833	·9838	·9843	1	1	2	2	3	3	4	4	5
80	·9848	·9853	·9858	·9863	·9868	·9872	1	1	1	2	2	3	3	4	4
81	·9877	·9881	·9886	·9890	·9894	·9899	0	1	1	2	2	3	3	3	4
82	·9903	·9907	·9911	·9914	·9918	·9922	0	1	1	2	2	2	3	3	3
83	9926	·9929	·9932	·9936	·9939	·9942	0	1	1	1	2	2	2	3	3
84	·9945	·9948	·9951	·9954	·9957	·9959	0	1	1	1	1	2	2	2	3
85	·9962	·9964	·9967	·9969	·9971	·9974	0	1	1	1	1	1	2	2	2
86	·9976	·9978	·9980	·9981	·9983	·9985	0	0	1	1	1	1	1	1	2
87	·9986	·9988	·9989	·9991	·9992	·9993	0	0	0	1	1	1	1	1	1
88	·9994	·9995	·9996	·9997	·9997	·9998	0	0	0	0	0	1	1	1	1
89	·9999	·9999	·9999	1·0000	1·0000	1·0000	0	0	0	0	0	0	0	0	0
90	1·0000														

Table IV

NATURAL TANGENTS

	0′	10′	20′	30′	40′	50′	Differences. 1′ 2′ 3′	4′ 5′ 6′	7′ 8′ 9′
0°	·0000	0029	0058	0087	0116	0145	3 6 9	12 15 18	20 23 26
1	·0175	0204	0233	0262	0291	0320	3 6 9	12 15 18	20 23 26
2	·0349	0378	0407	0437	0466	0495	3 6 9	12 15 18	20 23 26
3	·0524	0553	0582	0612	0641	0670	3 6 9	12 15 18	20 23 26
4	·0699	0729	0758	0787	0816	0846	3 6 9	12 15 18	20 23 26
5	·0875	0904	0934	0963	0992	1022	3 6 9	12 15 18	21 24 27
6	·1051	1080	1110	1139	1169	1198	3 6 9	12 15 18	21 24 27
7	·1228	1257	1287	1317	1346	1376	3 6 9	12 15 18	21 24 27
8	·1405	1435	1465	1495	1524	1554	3 6 9	12 15 18	21 24 27
9	·1584	1614	1644	1673	1703	1733	3 6 9	12 15 18	21 24 27
10	·1763	1793	1823	1853	1883	1914	3 6 9	12 15 18	21 24 27
11	·1944	1974	2004	2035	2065	2095	3 6 9	12 15 18	21 24 27
12	·2126	2156	2186	2217	2247	2278	3 6 9	12 15 18	21 24 28
13	·2309	2339	2370	2401	2432	2462	3 6 9	12 15 19	22 25 28
14	·2493	2524	2555	2586	2617	2648	3 6 9	12 16 19	22 25 28
15	·2679	2711	2742	2773	2805	2836	3 6 9	13 16 19	22 25 28
16	·2867	2899	2931	2962	2994	3026	3 6 9	13 16 19	22 25 29
17	·3057	3089	3121	3153	3185	3217	3 6 10	13 16 19	22 26 29
18	·3249	3281	3314	3346	3378	3411	3 6 10	13 16 19	23 26 29
19	·3443	3476	3508	3541	3574	3607	3 7 10	13 16 20	23 26 29
20	·3640	3673	3706	3739	3772	3805	3 7 10	13 17 20	23 27 30
21	·3839	3872	3906	3939	3973	4006	3 7 10	13 17 20	24 27 30
22	·4040	4074	4108	4142	4176	4210	3 7 10	14 17 21	24 27 31
23	·4245	4279	4314	4348	4383	4417	3 7 10	14 17 21	24 28 31
24	·4452	4487	4522	4557	4592	4628	4 7 11	14 18 21	25 28 32
25	·4663	4699	4734	4770	4806	4841	4 7 11	14 18 21	25 29 32
26	·4877	4913	4950	4986	5022	5059	4 7 11	15 18 22	25 29 33
27	·5095	5132	5169	5206	5243	5280	4 7 11	15 19 22	26 30 33
28	·5317	5354	5392	5430	5467	5505	4 8 11	15 19 23	26 30 34
29	·5543	5581	5619	5658	5696	5735	4 8 12	15 19 23	27 31 35
30	·5774	5812	5851	5890	5930	5969	4 8 12	16 20 24	27 31 35
31	·6009	6048	6088	6128	6168	6208	4 8 12	16 20 24	28 32 36
32	·6249	6289	6330	6371	6412	6453	4 8 12	16 21 25	29 33 37
33	·6494	6536	6577	6619	6661	6703	4 8 13	17 21 25	29 33 38
34	·6745	6787	6830	6873	6916	6959	4 9 13	17 21 26	30 34 39
35	·7002	7046	7089	7133	7177	7221	4 9 13	18 22 26	31 35 40
36	·7265	7310	7355	7400	7445	7490	5 9 14	18 23 27	32 36 41
37	·7536	7581	7627	7673	7720	7766	5 9 14	18 23 28	32 37 42
38	·7813	7860	7907	7954	8002	8050	5 10 14	19 24 29	33 38 43
39	·8098	8146	8195	8243	8292	8342	5 10 15	20 25 29	34 39 44
40	·8391	8441	8491	8541	8591	8642	5 10 15	20 25 30	35 40 45
41	·8693	8744	8796	8847	8899	8952	5 10 16	21 26 31	36 42 47
42	·9004	9057	9110	9163	9217	9271	5 11 16	21 27 32	38 43 48
43	·9325	9380	9435	9490	9545	9601	6 11 17	22 28 33	39 44 50
44	·9657	9713	9770	9827	9884	9942	6 11 17	23 29 34	40 46 52
	0′	10′	20′	30′	40′	50′	1′ 2′ 3′	4′ 5′ 6′	7′ 8′ 9′

Table IV

NATURAL TANGENTS

	0′	10′	20′	30′	40′	50′	Differences. 1	2	3	4	5	6	7	8	9
45°	1·0000	1·0058	1·0117	1·0176	1·0235	1·0295	6	12	18	24	30	36	41	47	53
46	1·0355	1·0416	1·0477	1·0538	1·0599	1·0661	6	12	18	25	31	37	43	49	55
47	1·0724	1·0786	1·0850	1·0913	1·0977	1·1041	6	13	19	25	32	38	45	51	57
48	1·1106	1·1171	1·1237	1·1303	1·1369	1·1436	7	13	20	26	33	40	46	53	60
49	1·1504	1·1571	1·1640	1·1708	1·1778	1·1847	7	14	21	28	35	41	48	55	62
50	1·1918	1·1988	1·2059	1·2131	1·2203	1·2276	7	14	22	29	36	43	50	58	65
51	1·2349	1·2423	1·2497	1·2572	1·2647	1·2723	8	15	23	30	38	45	53	60	68
52	1·2799	1·2876	1·2954	1·3032	1·3111	1·3190	8	16	23	31	39	47	55	63	70
53	1·3270	1·3351	1·3432	1·3514	1·3597	1·3680	8	16	25	33	41	49	58	66	74
54	1·3764	1·3848	1·3934	1·4019	1·4106	1·4193	9	17	26	34	43	52	60	69	78
55	1·4281	1·4370	1·4460	1·4550	1 4641	1·4733	9	18	27	36	45	54	63	73	82
56	1·4826	1·4919	1·5013	1·5108	1·5204	1·5301	10	19	29	38	48	57	67	76	86
57	1·5399	1·5497	1·5597	1·5697	1·5798	1·5900	10	20	30	40	50	60	71	81	91
58	1·6003	1·6107	1·6212	1·6319	1·6426	1·6534	11	21	32	43	53	64	75	85	96
59	1·6643	1·6753	1·6864	1·6977	1·7090	1·7205	11	23	34	45	57	68	79	90	102
60	1·7321	1·7437	1·7556	1·7675	1·7796	1·7917	12	24	36	48	60	72	84	96	108
61	1·8040	1·8165	1·8291	1·8418	1·8546	1·8676	13	26	38	51	64	77	89	102	115
62	1·8807	1·8940	1·9074	1·9210	1·9347	1·9486	14	27	41	55	68	82	95	109	122
63	1·9626	1·9768	1·9912	2·0057	2·0204	2·0353	15	29	44	58	73	88	102	117	131
64	2·0503	2·0655	2·0809	2·0965	2·1123	2·1283	16	31	47	63	79	94	110	126	141
65	2·1445	2·1609	2·1775	2·1943	2·2113	2·2286	17	34	51	68	85	101	118	135	152
66	2·2460	2·2637	2·2817	2·2998	2·3183	2·3369	18	37	55	74	92	110	128	146	165
67	2·3559	2·3750	2·3945	2·4142	2·4342	2·4545	20	40	60	79	100	119	149	159	179
68	2·4751	2·4960	2·5172	2·5386	2·5605	2·5826	22	43	65	87	109	130	152	174	195
69	2·6051	2·6279	2·6511	2·6746	2·6985	2·7228	24	47	71	95	119	142	166	190	213
70	2·7475	2·7725	2·7980	2·8239	2·8502	2·8770	26	52	78	104	131	157	183	209	235
71	2·9042	2·9319	2·9600	2·9887	3·0178	3·0475	29	58	87	116	145	174	202	231	260
72	3·0777	3·1084	3·1397	3·1716	3·2041	3·2371	32	64	97	132	161	193	225	258	290
73	3.2709	3·3052	3·3402	3·3759	3·4124	3·4495	36	72	108	144	181	216	253	289	325
74	3·4874	3·5261	3·5656	3·6059	3·6470	3·6891	41	81	122	163	204	244	285	326	366
75	3.7321	3.7760	3·8208	3·8667	3·9136	3·9617	46	93	139	185	232	278	325	371	418
76	4·0108	4·0611	4·1126	4·1653	4·2193	4·2747									
77	4·3315	4·3897	4·4494	4·5107	4·5736	4·6382									
78	4·7046	4·7729	4·8430	4·9152	4·9894	5·0658									
79	5·1446	5·2257	5·3093	5·3955	5·4845	5·5764									
80	5·6713	5·7694	5·8708	5·9758	6·0844	6·1970									
81	6·3138	6·4348	6·5606	6·6912	6·8269	6·9682									
82	7·1154	7·2687	7·4287	7·5958	7·7704	7·9530									
83	8·1443	8·3450	8·5555	8·7769	9·0098	9·2553									
84	9·5144	9·7882	10·078	10·385	10·712	11·059									
85	11·430	11·826	12·251	12·706	13·197	13·727									
86	14·301	14·924	15·605	16·350	17·169	18·075									
87	19·081	20·206	21·470	22·904	24·542	26·432									
88	28·636	31·242	34·368	38·188	42·964	49·104									
89	57·290	68·750	85·940	114·59	171·89	343·77									

Differences change so rapidly that they cease to be useful.

| | 0′ | 10′ | 20′ | 30′ | 40′ | 50′ |

Table V

RECIPROCALS

	0	1	2	3	4	5	6	7	8	9
10	·1000	0990	0980	0971	0962	0952	0943	0935	0926	0917
11	·0909	0901	0893	0885	0877	0870	0862	0855	0848	0840
12	·0833	0826	0820	0813	0807	0800	0794	0787	0781	0775
13	·0769	0763	0758	0752	0746	0741	0735	0730	0725	0719
14	·0714	0709	0704	0699	0694	0690	0685	0680	0676	0671
15	·0667	0662	0658	0654	0649	0645	0641	0637	0633	0629
16	·0625	0621	0617	0614	0610	0606	0602	0599	0595	0592
17	·0588	0585	0581	0578	0575	0571	0568	0565	0562	0559
18	·0556	0553	0550	0546	0544	0541	0538	0535	0532	0529
19	·0526	0524	0521	0518	0516	0513	0510	0508	0505	0503
20	·0500	0498	0495	0493	0490	0488	0485	0483	0481	0479
21	·0476	0474	0472	0470	0467	0465	0463	0461	0459	0457
22	·0455	0453	0451	0448	0446	0444	0443	0441	0439	0437
23	·0435	0433	0431	0429	0427	0426	0424	0422	0420	0418
24	·0417	0415	0413	0412	0410	0408	0407	0405	0403	0402
25	·0400	0398	0397	0395	0394	0392	0391	0389	0388	0386
26	·0385	0383	0382	0380	0379	0377	0376	0375	0373	0372
27	·0370	0369	0368	0366	0365	0364	0362	0361	0360	0358
28	·0357	0356	0355	0353	0352	0351	0350	0348	0347	0346
29	·0345	0344	0343	0341	0340	0339	0338	0337	0336	0334
30	·0333	0332	0331	0330	0329	0328	0327	0326	0325	0324
31	·0323	0322	0321	0320	0319	0318	0317	0316	0315	0314
32	·0313	0312	0311	0310	0309	0308	0307	0306	0305	0304
33	·0303	0302	0301	0300	0299	0299	0298	0297	0296	0295
34	·0294	0293	0292	0292	0291	0290	0289	0288	0287	0287
35	·0286	0285	0284	0283	0283	0282	0281	0280	0279	0279
36	·0278	0277	0276	0276	0275	0274	0273	0273	0272	0271
37	·0270	0270	0269	0268	0267	0267	0266	0265	0265	0264
38	·0263	0263	0262	0261	0260	0260	0259	0258	0258	0257
39	·0256	0256	0255	0255	0254	0253	0253	0252	0251	0251
40	·0250	0249	0249	0248	0248	0247	0246	0246	0245	0245
41	·0244	0243	0243	0242	0242	0241	0240	0240	0239	0239
42	·0238	0238	0237	0236	0236	0235	0235	0234	0234	0233
43	·0233	0232	0232	0231	0230	0230	0229	0229	0228	0228
44	·0227	0227	0226	0226	0225	0225	0224	0224	0223	0223
45	·0222	0222	0221	0221	0220	0220	0219	0219	0218	0218
46	·0217	0217	0217	0216	0216	0215	0215	0214	0214	0213
47	·0213	0212	0212	0211	0211	0211	0210	0210	0209	0209
48	·0208	0208	0208	0207	0207	0206	0206	0205	0205	0205
49	·0204	0204	0203	0203	0202	0202	0202	0201	0201	0200
50	·0200	0200	0199	0199	0198	0198	0198	0197	0197	0197
51	·0196	0196	0195	0195	0195	0194	0194	0193	0193	0193
52	·0192	0192	0192	0191	0191	0191	0190	0190	0189	0189
53	·0189	0188	0188	0188	0187	0187	0187	0186	0186	0186
54	·0185	0185	0185	0184	0184	0184	0183	0183	0183	0182
	0	1	2	3	4	5	6	7	8	9

Table V

RECIPROCALS

	0	1	2	3	4	5	6	7	8	9
55	·0182	0182	0181	0181	0181	0180	0180	0180	0179	0179
56	·0179	0178	0178	0178	0177	0177	0177	0176	0176	0176
57	·0175	0175	0175	0175	0174	0174	0174	0173	0173	0173
58	·0172	0172	0172	0172	0171	0171	0171	0170	0170	0170
59	·0170	0169	0169	0169	0168	0168	0168	0168	0167	0167
60	·0167	0166	0166	0166	0166	0165	0165	0165	0165	0164
61	·0164	0164	0163	0163	0163	0163	0162	0162	0162	0162
62	·0161	0161	0161	0161	0160	0160	0160	0160	0159	0159
63	·0159	0159	0158	0158	0158	0158	0157	0157	0157	0157
64	·0156	0156	0156	0156	0155	0155	0155	0155	0154	0154
65	·0154	0154	0153	0153	0153	0153	0152	0152	0152	0152
66	·0152	0151	0151	0151	0151	0150	0150	0150	0150	0150
67	·0149	0149	0149	0149	0148	0148	0148	0148	0148	0147
68	·0147	0147	0147	0146	0146	0146	0146	0146	0145	0145
69	·0145	0145	0145	0144	0144	0144	0144	0144	0143	0143
70	·0143	0143	0143	0142	0142	0142	0142	0141	0141	0141
71	·0141	0141	0140	0140	0140	0140	0140	0140	0139	0139
72	·0139	0139	0139	0138	0138	0138	0138	0138	0137	0137
73	·0137	0137	0137	0136	0136	0136	0136	0136	0136	0135
74	·0135	0135	0135	0135	0134	0134	0134	0134	0134	0134
75	·0133	0133	0133	0133	0133	0133	0132	0132	0132	0132
76	·0132	0131	0131	0131	0131	0131	0131	0130	0130	0130
77	·0130	0130	0130	0129	0129	0129	0129	0129	0129	0128
78	·0128	0128	0128	0128	0128	0127	0127	0127	0127	0127
79	·0127	0126	0126	0126	0126	0126	0126	0126	0125	0125
80	·0125	0125	0125	0125	0124	0124	0124	0124	0124	0124
81	·0124	0123	0123	0123	0123	0123	0123	0122	0122	0122
82	·0122	0122	0122	0122	0121	0121	0121	0121	0121	0121
83	·0121	0120	0120	0120	0120	0120	0120	0120	0119	0119
84	·0119	0119	0119	0119	0119	0118	0118	0118	0118	0118
85	·0118	0118	0117	0117	0117	0117	0117	0117	0117	0116
86	·0116	0116	0116	0116	0116	0116	0116	0115	0115	0115
87	·0115	0115	0115	0115	0114	0114	0114	0114	0114	0114
88	·0114	0114	0113	0113	0113	0113	0113	0113	0113	0113
89	·0112	0112	0112	0112	0112	0112	0112	0112	0111	0111
90	·0111	0111	0111	0111	0111	0111	0110	0110	0110	0110
91	·0110	0110	0110	0110	0109	0109	0109	0109	0109	0109
92	·0109	0109	0109	0108	0108	0108	0108	0108	0108	0108
93	·0108	0107	0107	0107	0107	0107	0107	0107	0107	0107
94	·0106	0106	0106	0106	0106	0106	0106	0106	0106	0105
95	·0105	0105	0105	0105	0105	0105	0105	0105	0104	0104
96	·0104	0104	0104	0104	0104	0104	0104	0103	0103	0103
97	·0103	0103	0103	0103	0103	0103	0103	0102	0102	0102
98	·0102	0102	0102	0102	0102	0102	0101	0101	0101	0101
99	·0101	0101	0101	0101	0101	0101	0100	0100	0100	0100
	0	1	2	3	4	5	6	7	8	9

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